NASA Phase II SBIR
Very Large Solar Rejection Filter For Laser Communication
(Status Report; 6/7/10)

Surface Optics Corporation

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Presentation Outline

- Project background + 2009 result (1st quarter)
- Filter performance improvements (what was learned this year)
- How SOC motion-controlled coating system works
- System improvements
- Application of system improvements to other coating projects (dielectric mirror, LLNL AR coating).

Daylight, interplanetary laser communication

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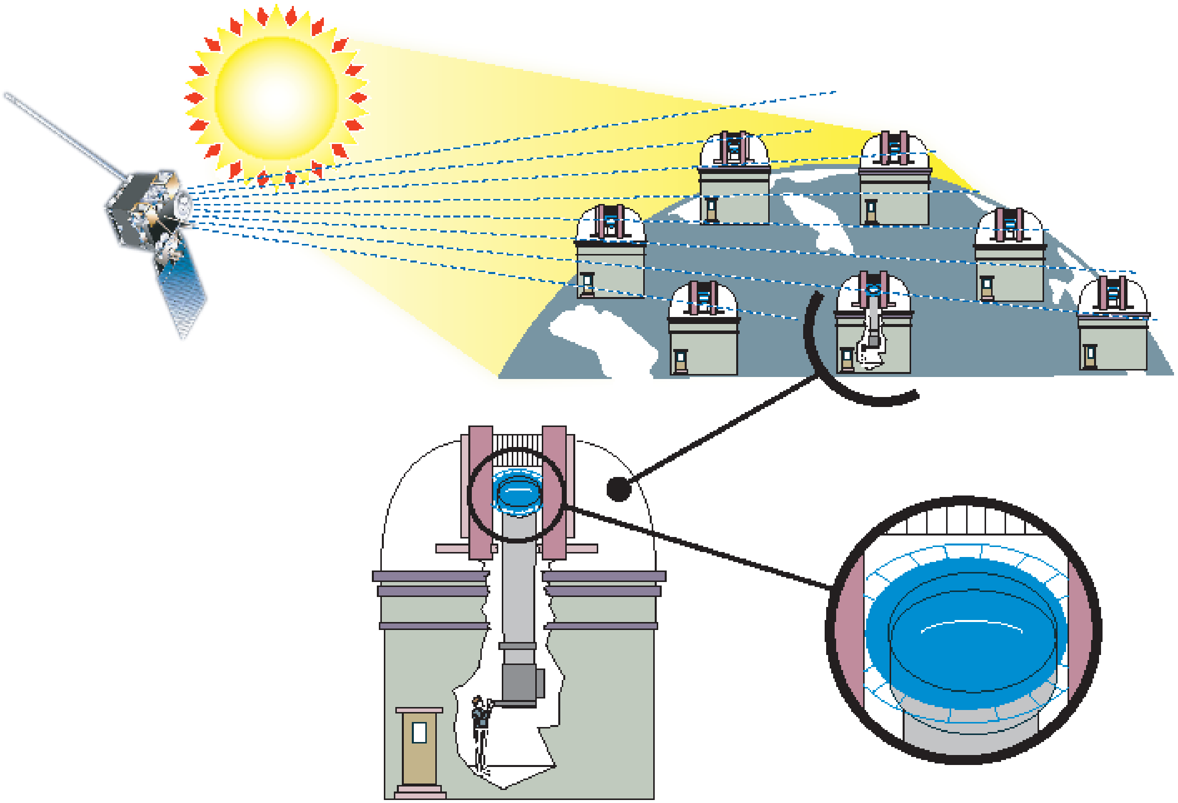
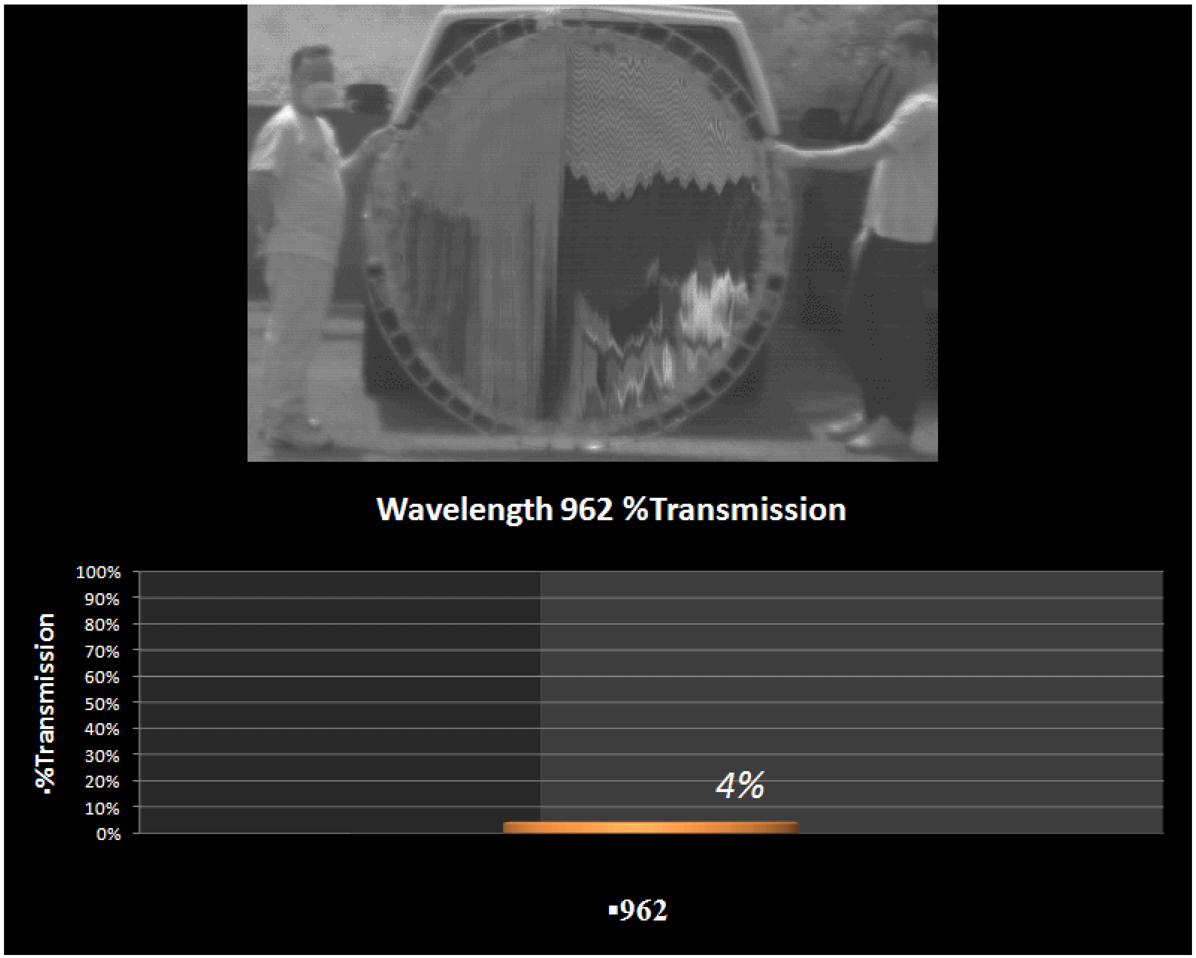


IR Hyperspectral Imaging Of Band-pass Filter



1.5-m Membrane Filter (2009)

Issues related to coated membranes

- Adhesion of coatings to membrane
- Coating stress
- Mounting and tensioning of membrane
- CTE match between mounting frame, membrane and coating
- Choice of coating materials
  - Cracking
  - Stress

Filter Requirements

PARAMETER	SPECIFICATION
Transmission	90% external transmission from 1540-1560-nm
Incident Angle	0.0 +/- 2.0°
Blocking	Block transmission of the complete incident solar power spectrum to a level of: 97% over angles from 0-30° from the filter normal 95% over angles from 30-60° from the filter normal
Polarization	Non-polarizing to within 1% at normal incidence
Absorption	Absorbs less than 10% of incident solar power
Scatter	BRDF at 3° from normal < 0.014 sr^{-1} at 1064 nm
Operating Temp	-10°C to +60°C
Shape/Size	2.2-meters circular aperture
Thickness	< 50 microns total (membrane + coatings)
Uniformity	All specifications must be met when averaged over entire filter area
Wavefront	$\lambda/2$ at 1550-nm

Summary, since last year -

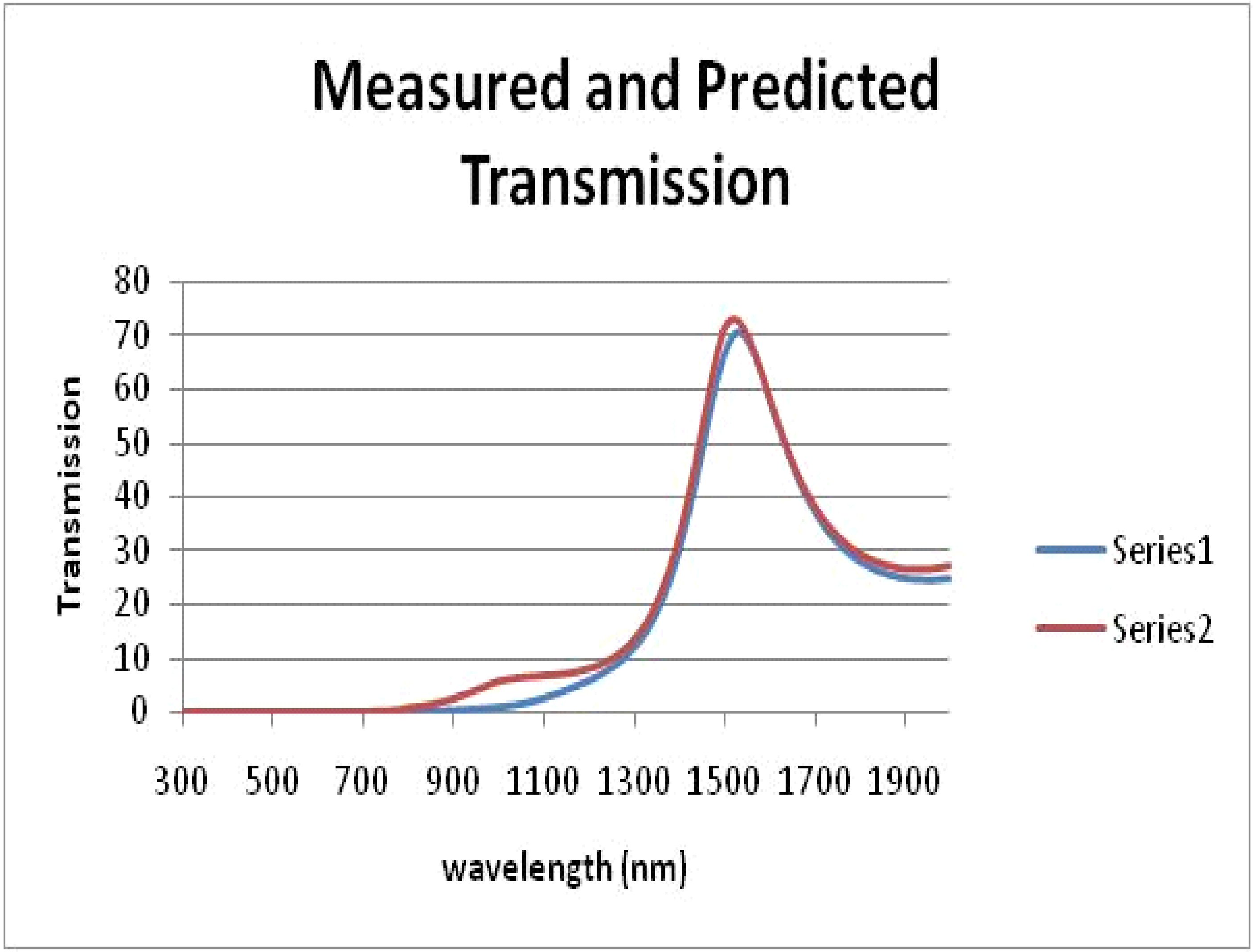
•Membrane filter (#2) was constructed using a 15-layer design (last year's design was 11-layers). 1550-nm transmission improved from low 70's to mid 80's (goal is greater than 90%).

•Glass dielectric mirror fabricated which transmits above 750-nm

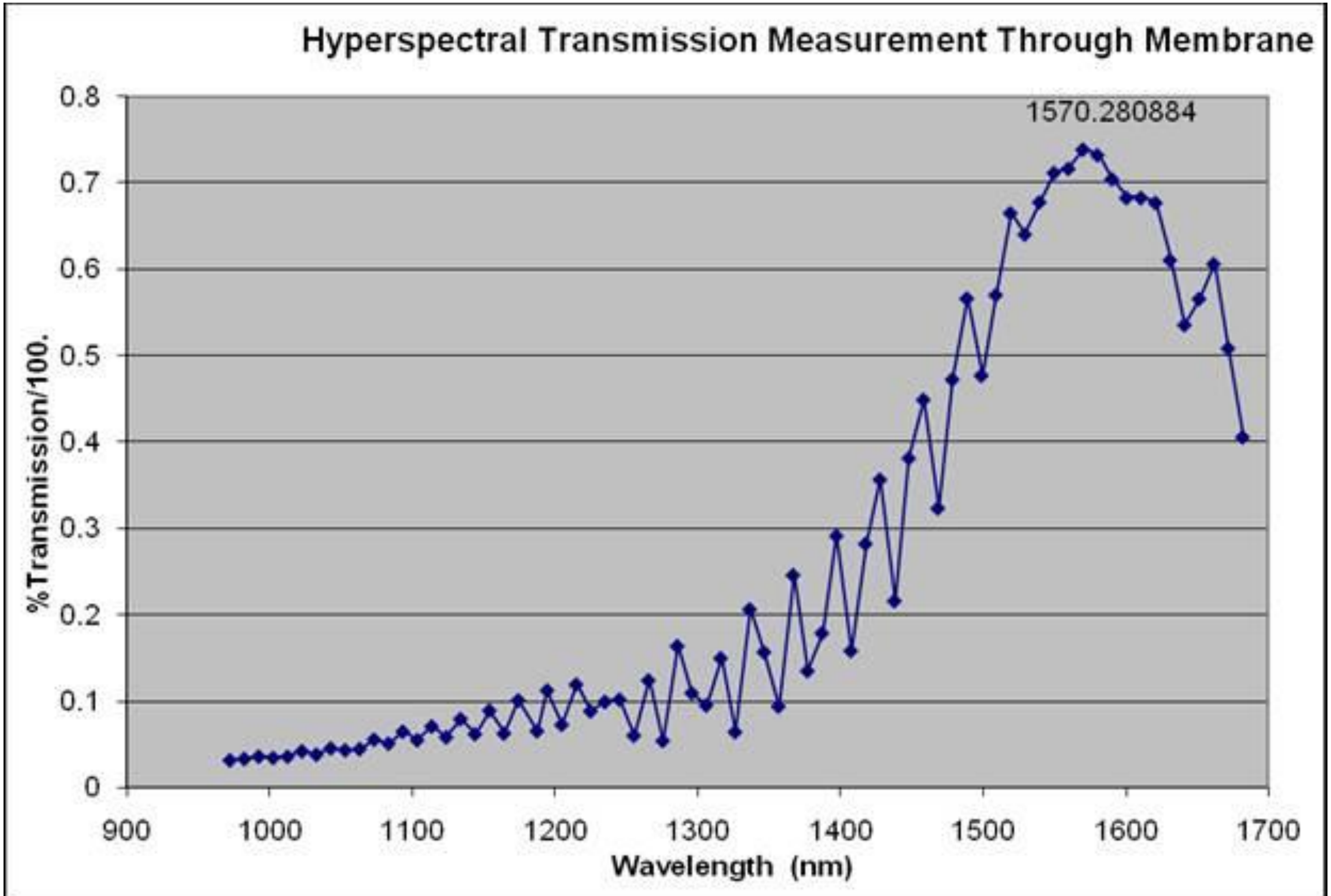
•AR Coating of LLNL Observation Window (<0.5% reflection and <u>uniform</u> from center to edge)

•Hardware and software changes

11-Layer Design (front & back) On Glass (6/09)

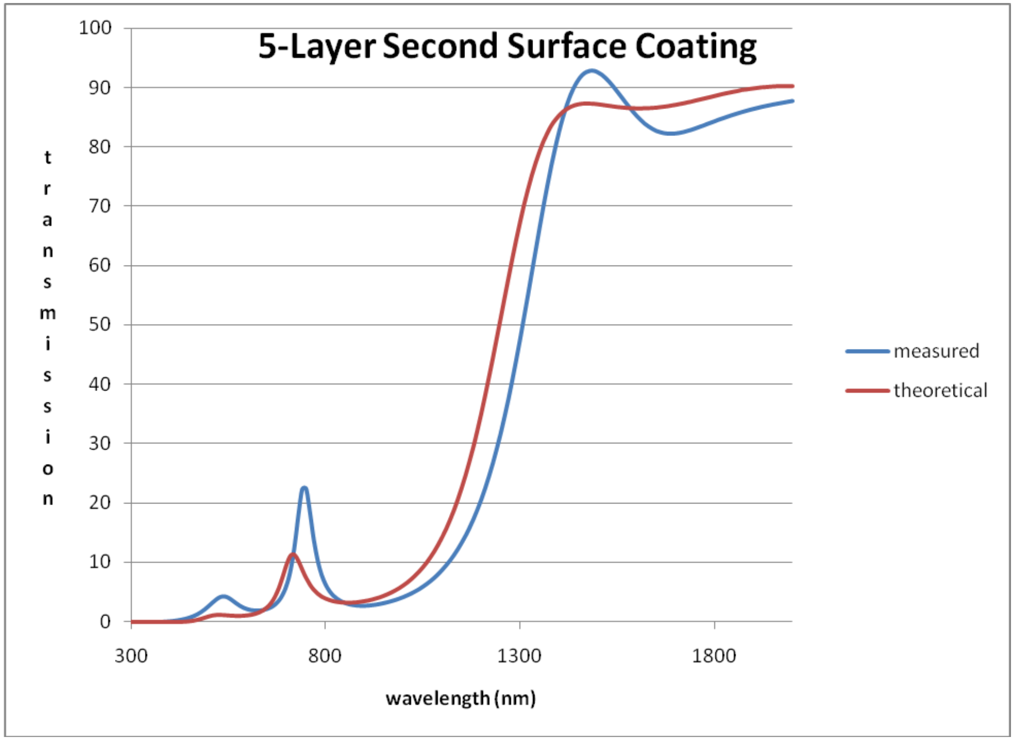


Data for 11-layer Coating (front & back) on Membrane #1 (2009)

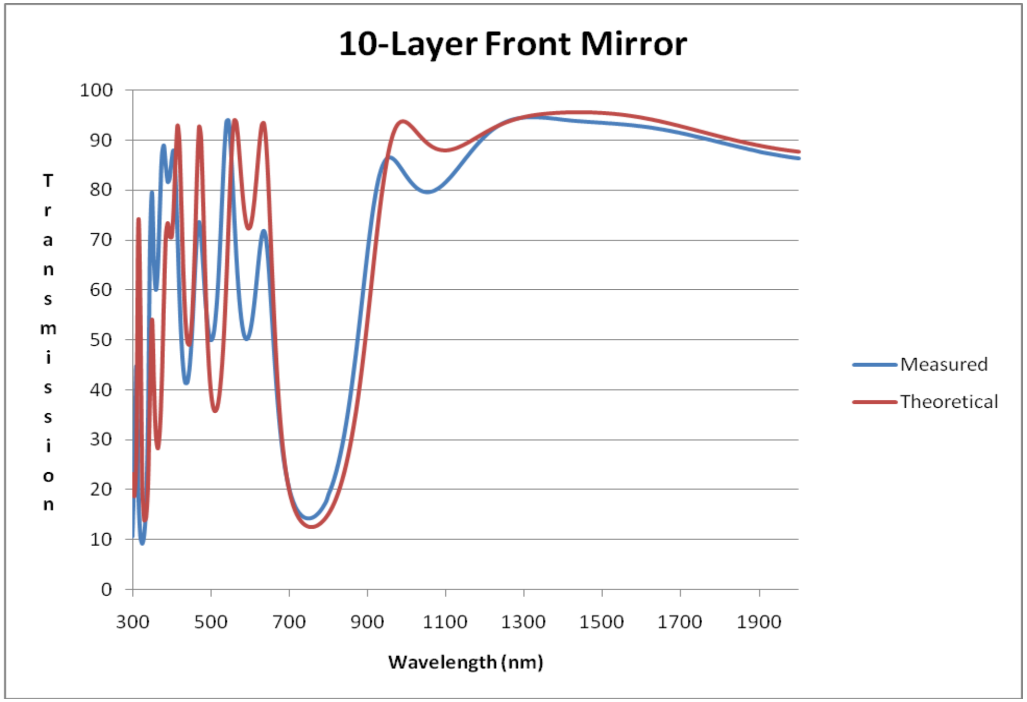


15-layer coating (front & back) (Feb-2010)

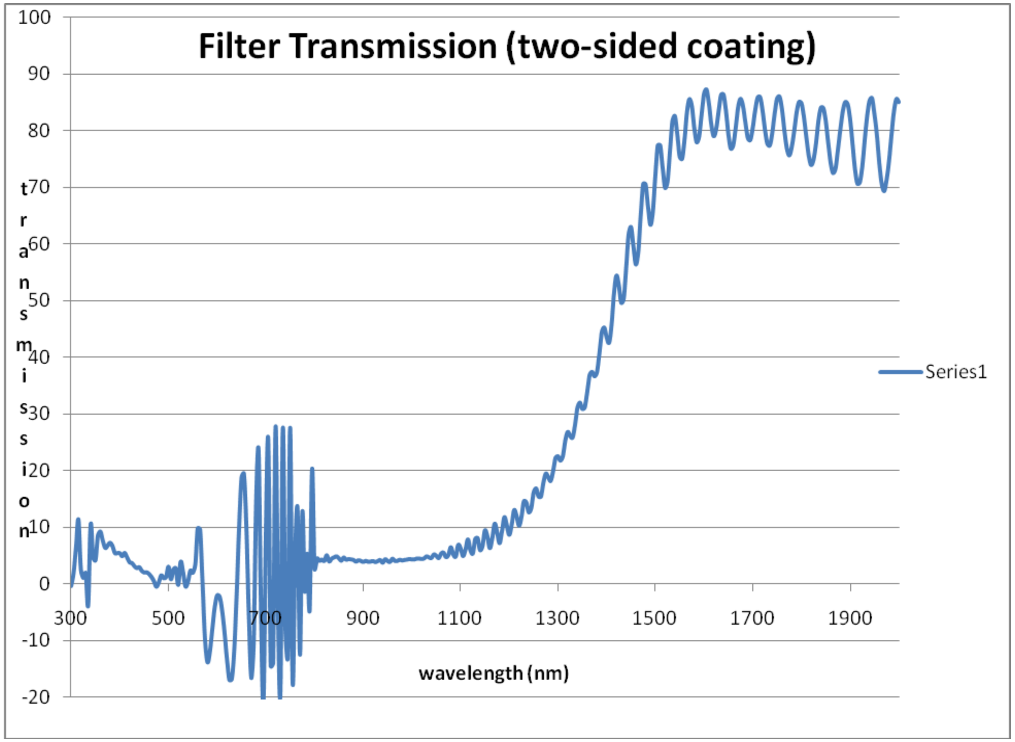
5-layer 2nd surface coating has excellent T@1550-nm and provides good out-of-band blocking (on glass substrate)



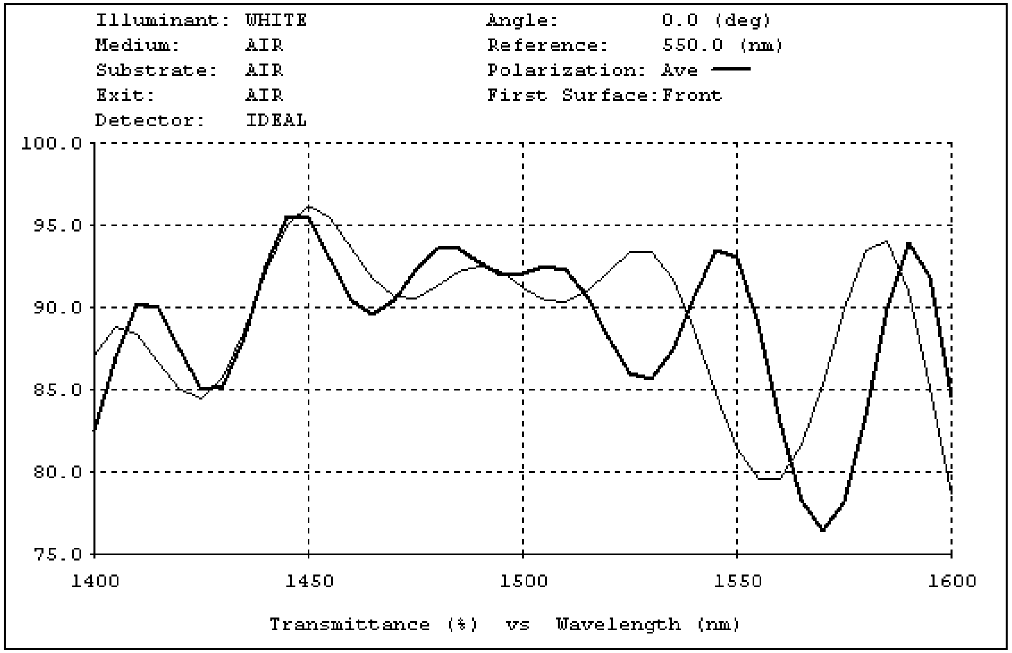
10-layer dielectric mirror reflects energy just below 800-nm and is AR @1550-nm (on glass substrate)



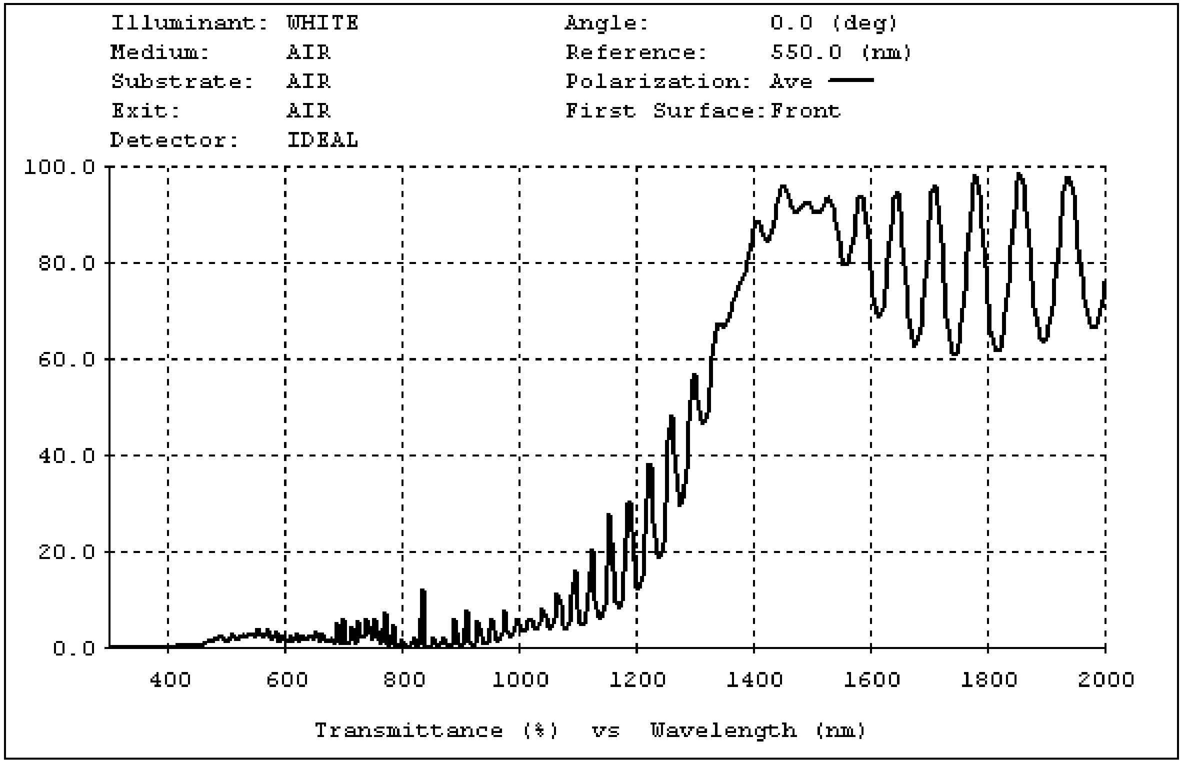
Measured Data off Back Wall of Integrating Sphere for 15-layer Filter (on membrane substrate)



Effect of Substrate Thickness on Position of Interference Maxima and Minima for 1550-nm Laser Transmission (12-μ and 16-μ Al_2O3 substrates).



Predicted Performance of 15-layer, Two-Sided Coating on Al2O3 Substrate

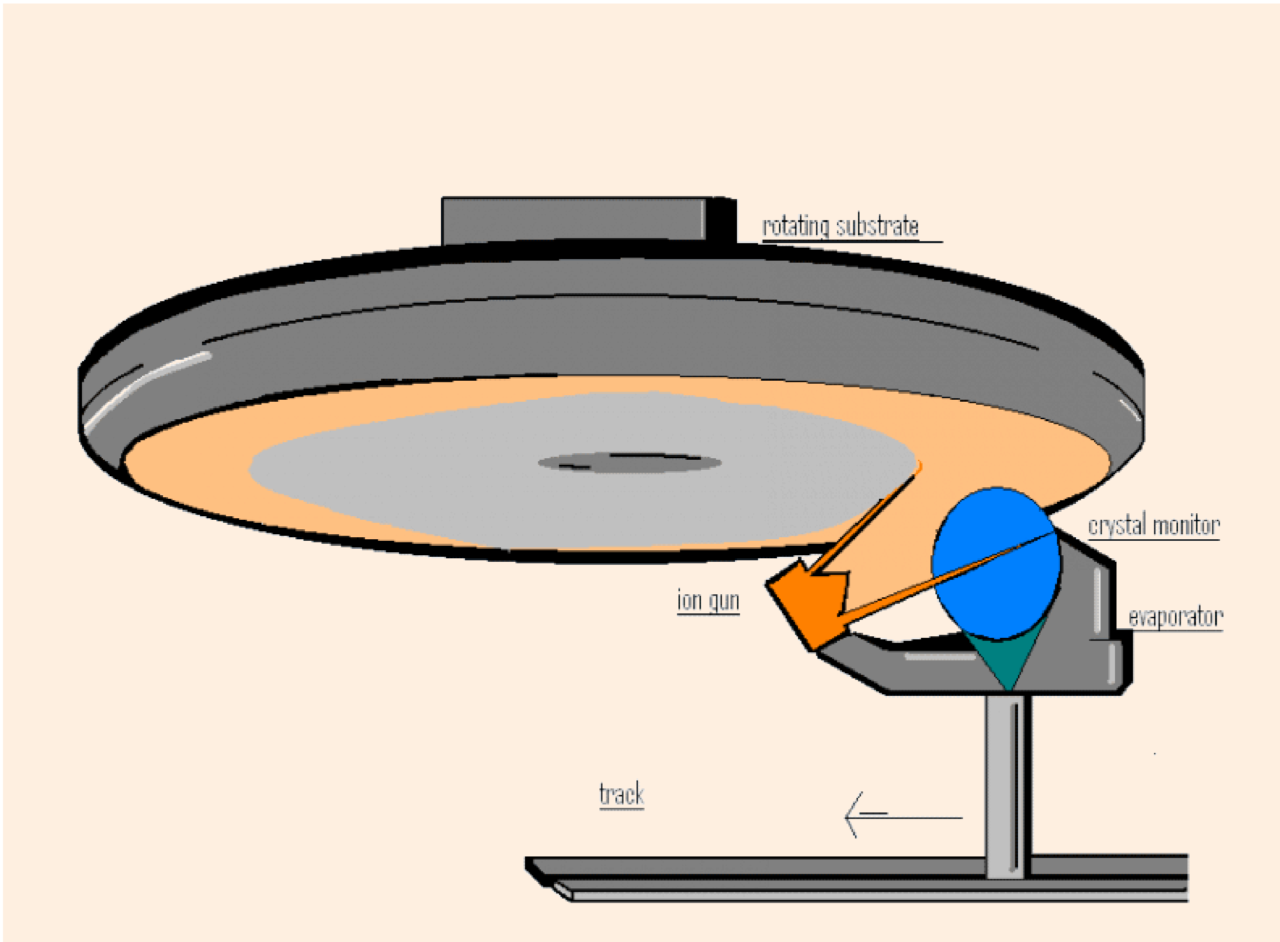


Progress Summary

- LAST YEAR (June 2009)
- All dielectric and semi-conductor design
- 2-sided design, 10-layers on front and 1-layer on back of membrane
- ~70% Transmission @1550
- Solar A & T still need improvement (more layers)

- THIS YEAR (June 2010)
- All dielectric and semi-conductor design
- 2-sided design, 10-layers on front and 5-layer on back of membrane
- ~80+% Transmission @1550
- Solar A & T still need improvement (more layers)

Animation of motion system



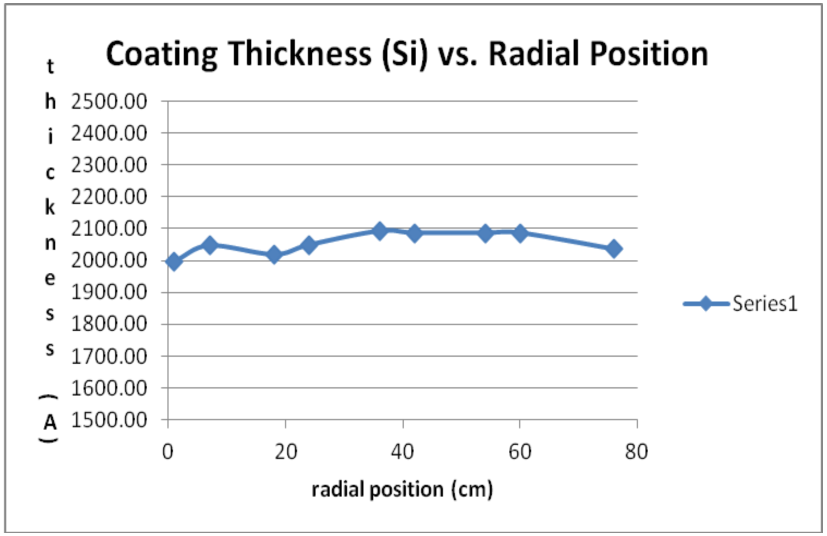
Past Year's Improvement Objectives

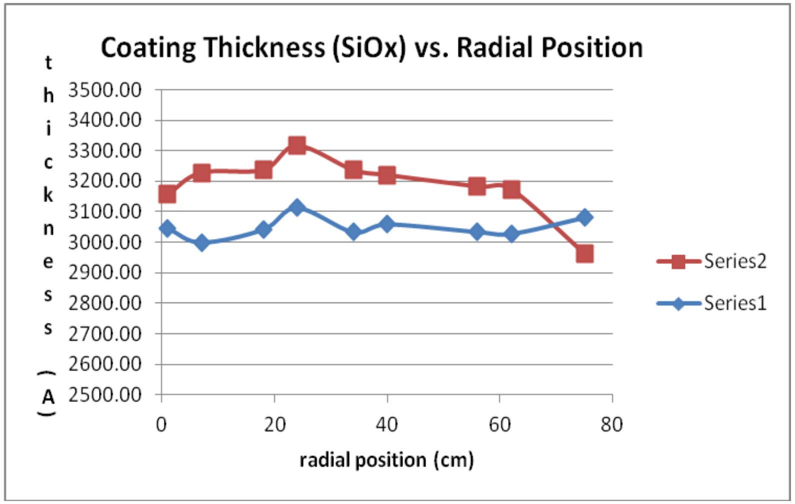
- The Phase II effort has focused on improved coating layer thickness control.
  - Hardware Changes
    - Addition of crystal micro-balance sensors + crystal averaging.
    - Second, resistive evaporation source
    - Increased ion current
  - Software Changes
    - Maximum number of deposition positions (non-uniform increments)
    - System of 'rules' to determine how layers are deposited
  - Process Changes
    - Coat only from center outward, rather than back and forth

Specific Technical Problems To Solve & How?

- Coating uniformity (flatness) at center
  - Vary coating step sizes (use minimum that motion system can ‘keep up with’); computed with software algorithm
  - Coat from center to edge (rather than back and forth). This prevents ‘over-shooting’ on the way IN.
- Absolute coating thickness (how to consistently hit target thickness)
  - Multi-crystal averaging
  - Addition of crystal near plume center

Absolute and Relative Coating Thickness of Based on 2009 ‘Coating Techniques’





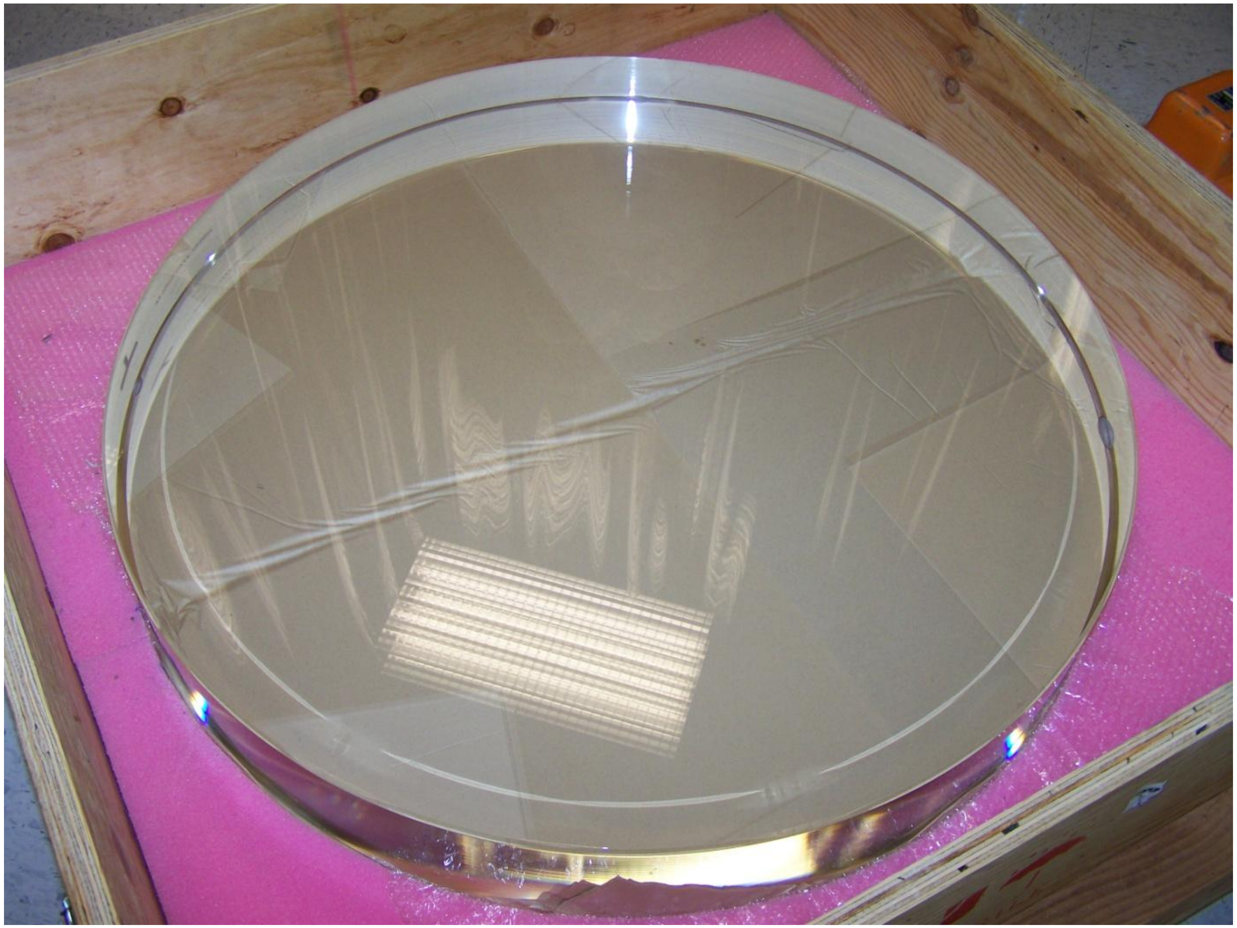
How is SOC applying these Phase II process improvements and innovations, to other US government coating needs?

- THESE PROJECTS WERE NOT POSSIBLE FOR SOC TO SUCCESSFULLY COMPLETE IN 2009 and WERE COMPLETED THIS YEAR!

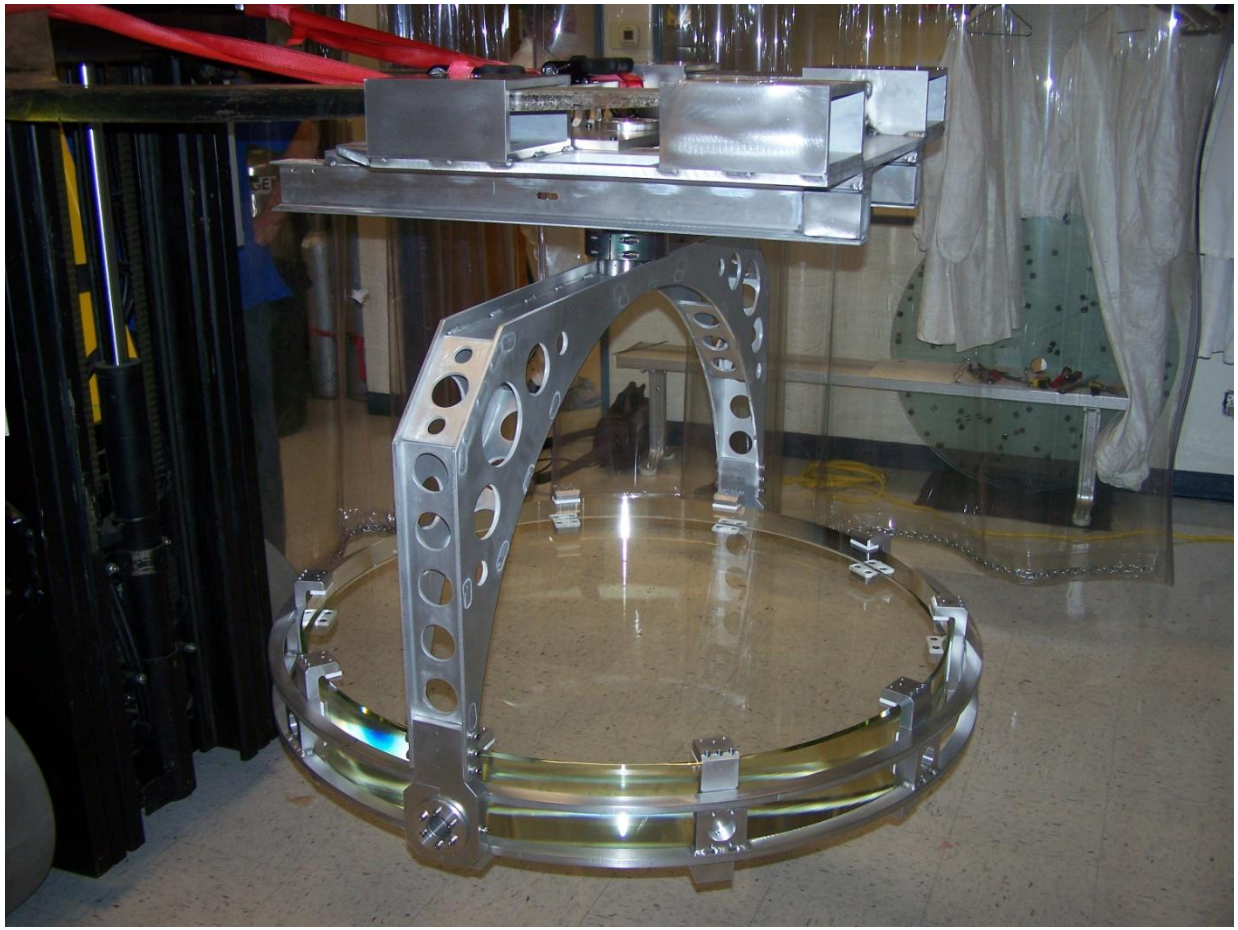
- All-dielectric visible mirror with high transmission in near IR (cold mirror)
- AR-Coating for LLNL Observation Window

National Ignition Facility at LLNL

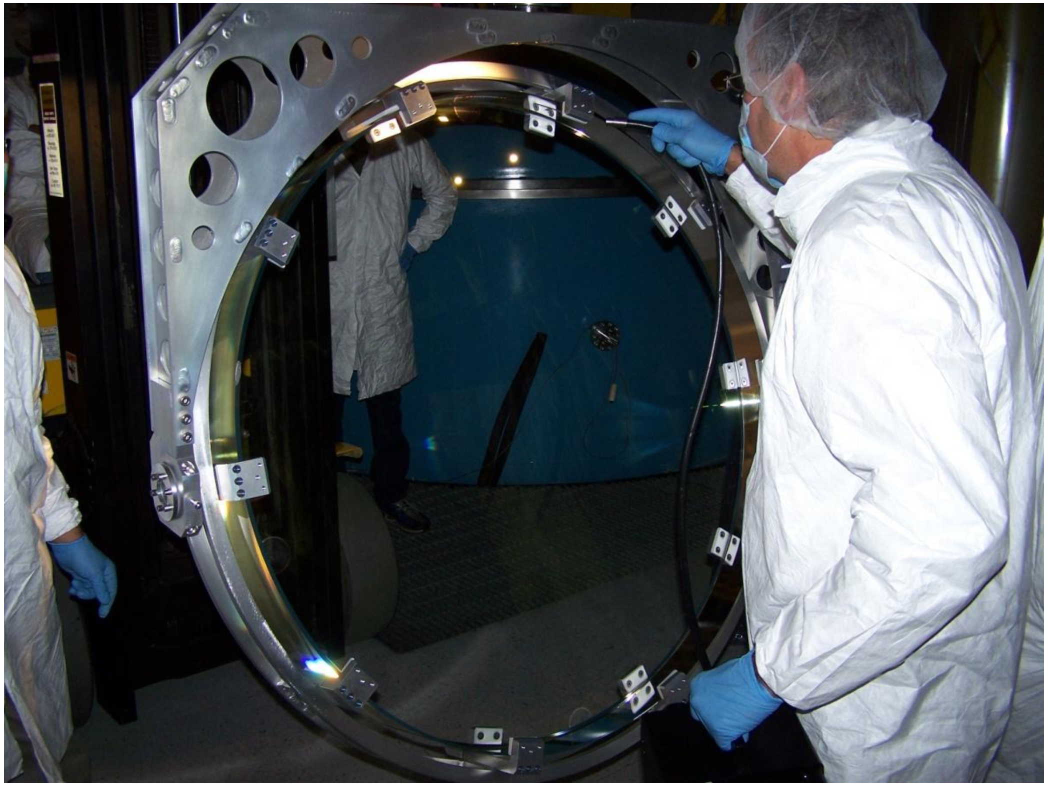
LLNL Window (40” diameter, 6” thick)



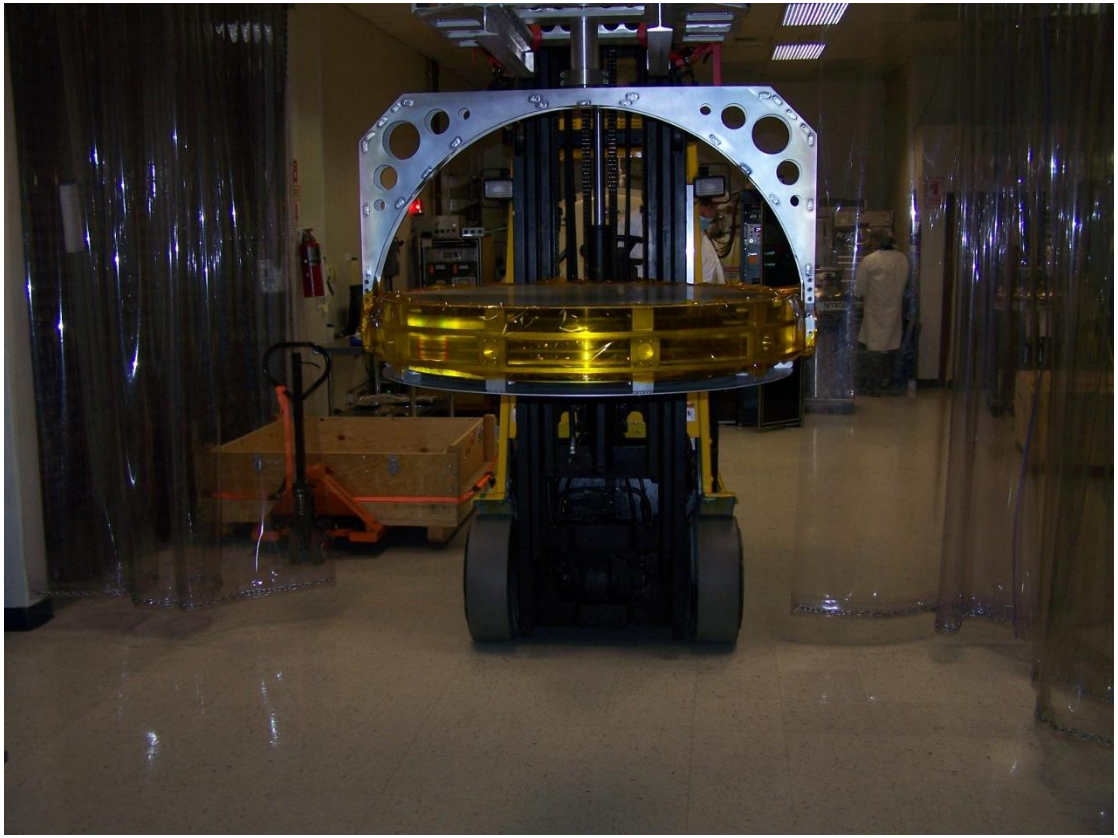
LLNL Window in Rotation Fixture



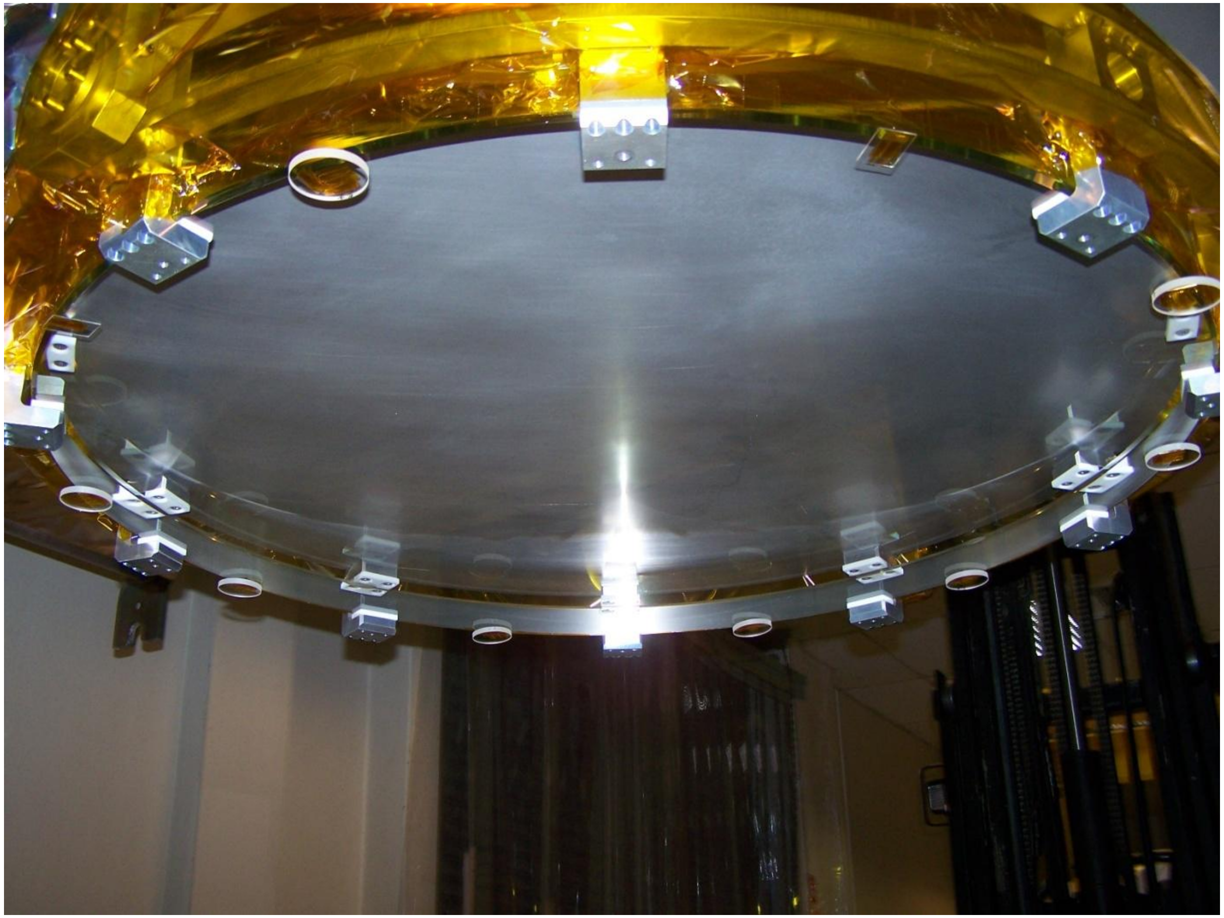
LLNL Window After Coating First Side



LLNL Window Moved Into Chamber



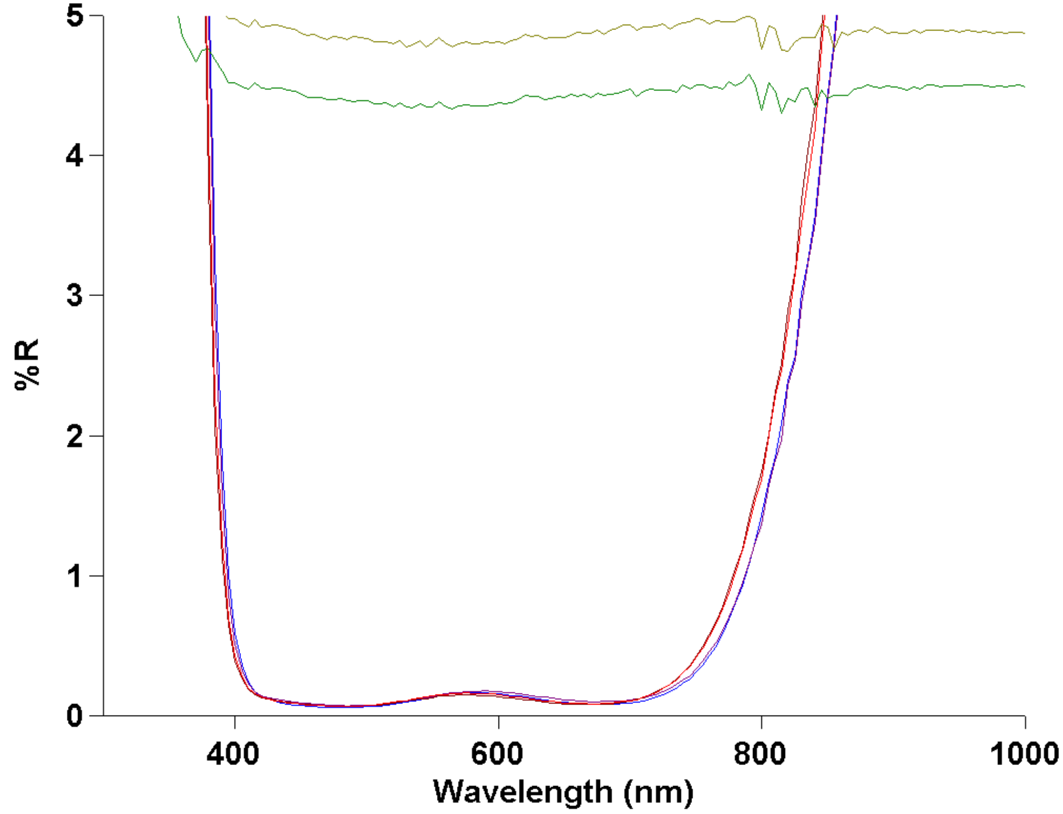
LLNL Masked and Witness Coupons Added



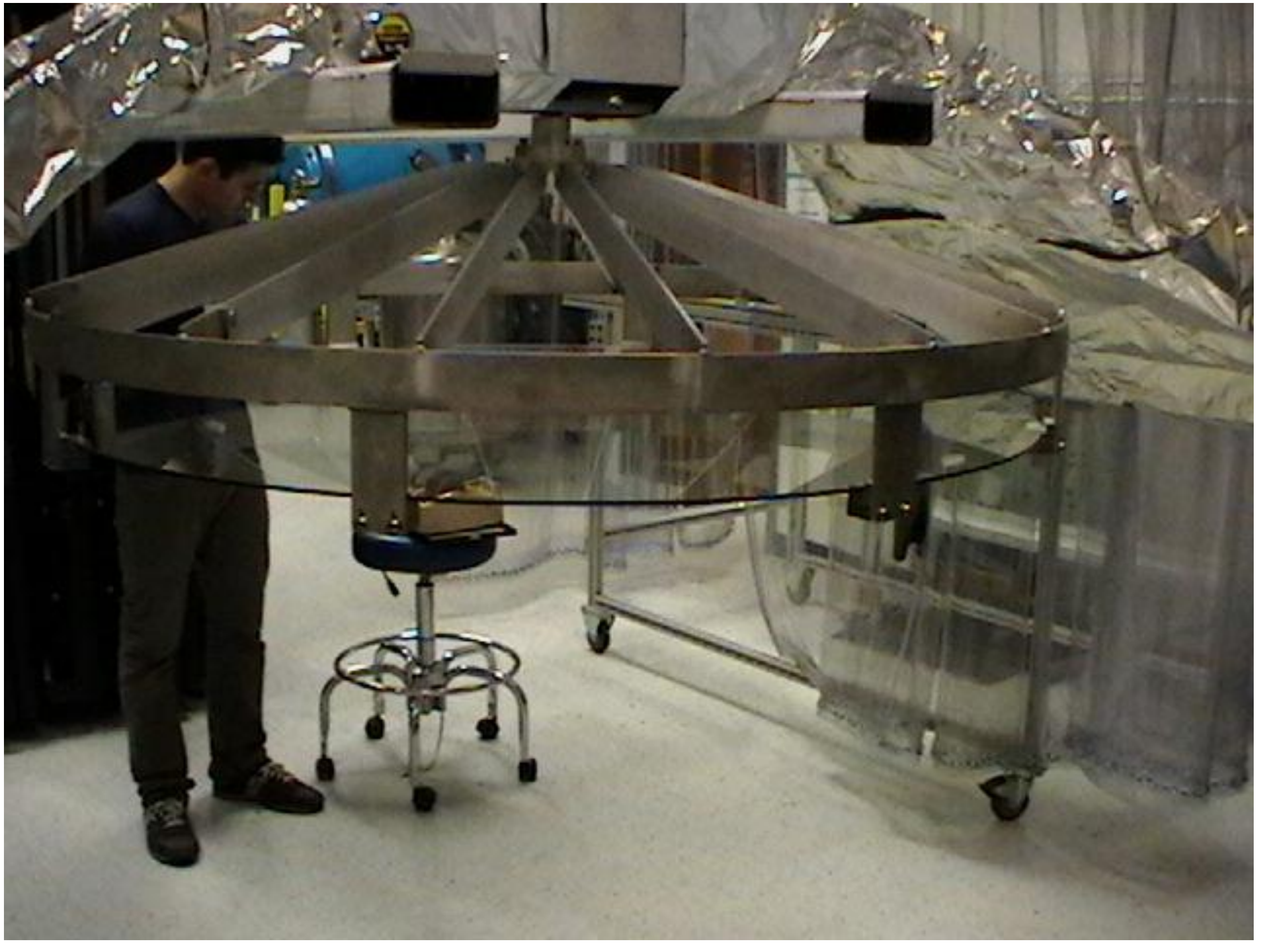
Window in Fixture

Cleaning second surface prior to coating

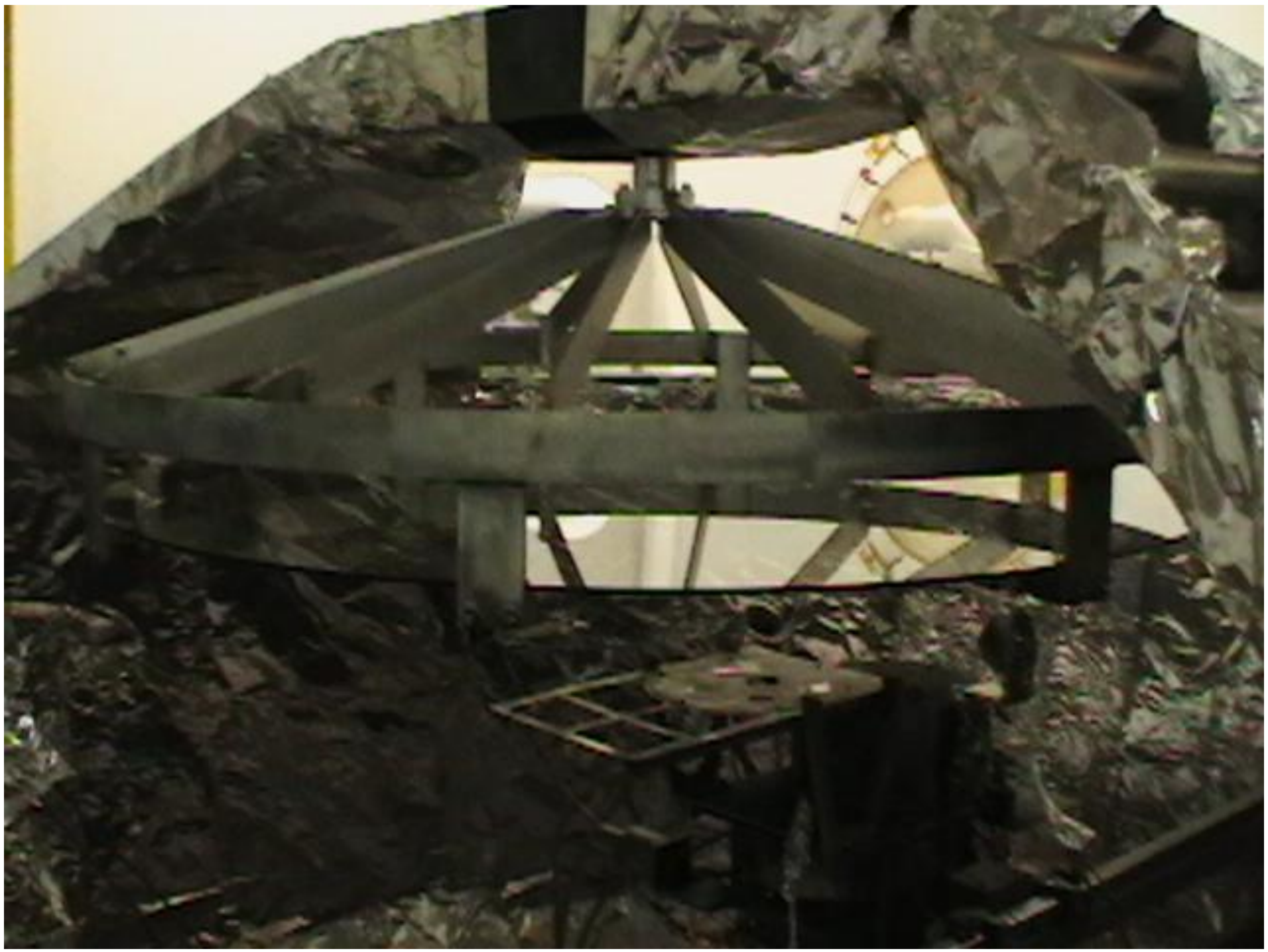
4-layer Low Reflectance Coating



Fabrication of 1.5-m dielectric mirror



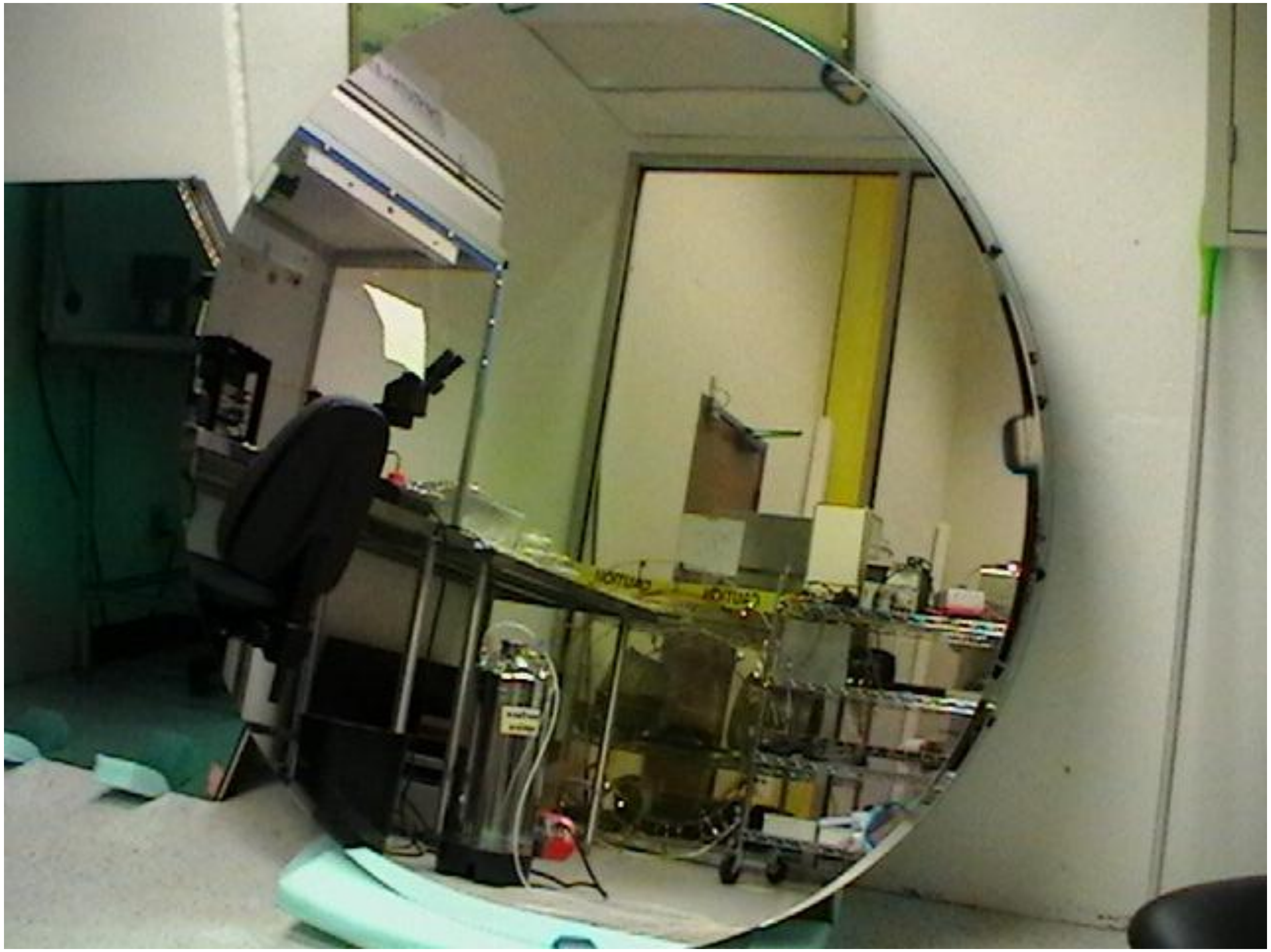
1.5-m Mirror Installed in Chamber

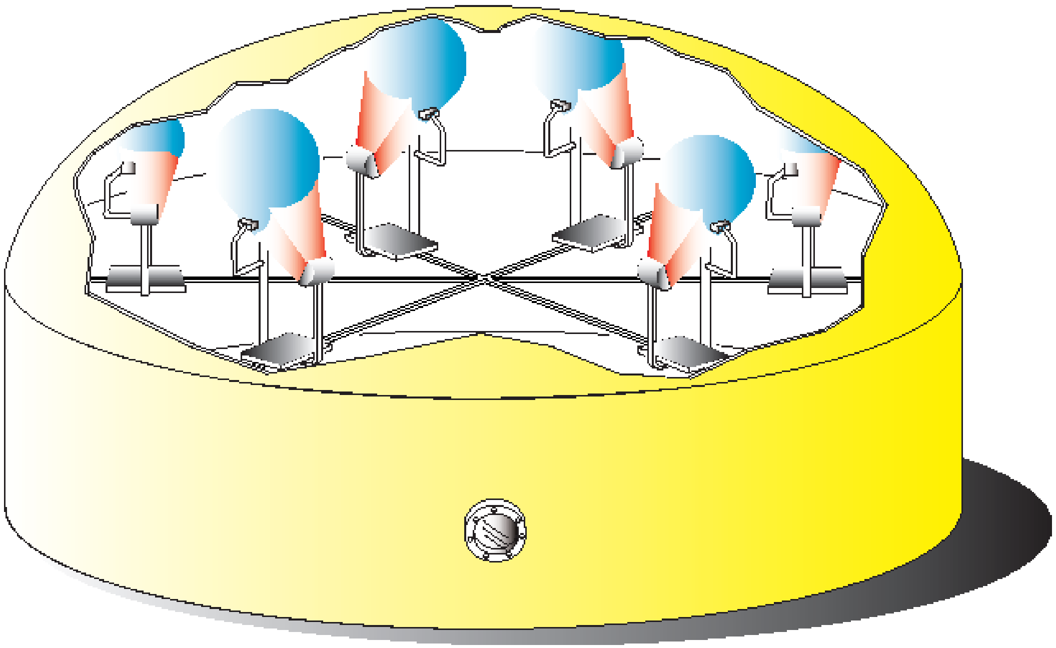


1.5-m Mirror; After Coating

At high angle, 1.5-mirror has blue color

Finished Mirror Transmits Above 750-nm





The End
QUESTIONS?